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(71) Applicants
National Research Development Corporation,
P.O. Box 236, Kingsgate House, 66—74 Victoria Street, London, SW1E 6SL
(72) Inventor
Alfred Roy Taylor
(74) Agent
G. Parker,
Patent Department, National Research Development Corporation, P.O. Box 236, Kingsgate House, 66—74 Victoria Street, London, SW1E 6SL

(54) **Orthopaedic fracture fixation apparatus**

(57) Orthopaedic fracture fixation apparatus including at least one elongate member (10, 11) located externally of the patient and connected with bone pins (12) secured in the different fragments of a fractured bone (13), the member and pins forming a rigid framework holding the fragments in a desired relationship for union, is simplified but still applicable in varying configurations by the provision of said member as an elongate carrier (10) of flexible form and charged with a hardenable material (11) normally held by the carrier in an inactive fluent state. The carrier is suitably a closed tube or a permeable rope respectively holding or impregnated with the material. The material can be hardenable by radiant energy such as heat or light, or by chemical action, the latter case suitably involving a tube divided into compartments by a rupturable wall to hold respective constituents of a hardenable mixture.

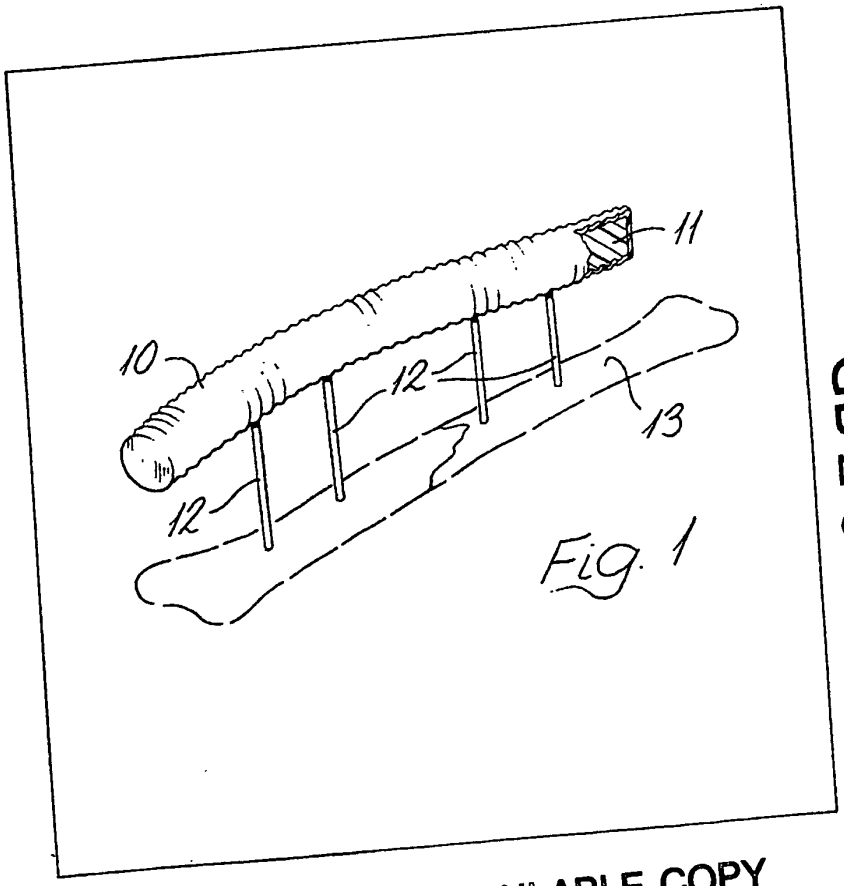

Fig. 1

GB 2 086 231 A

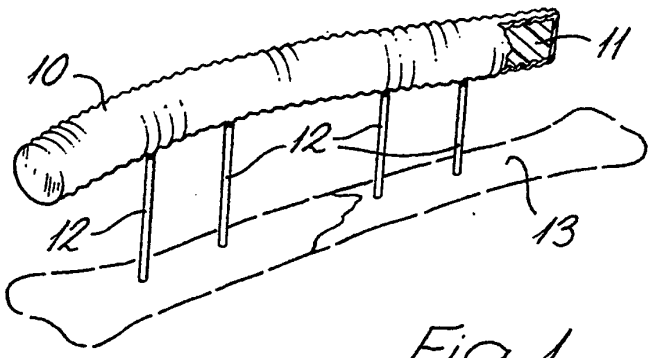

Fig. 1

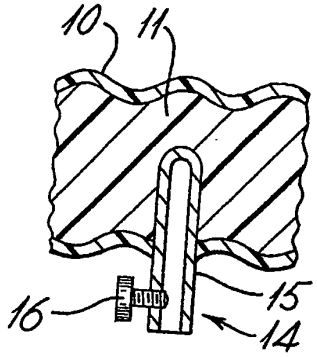

Fig. 2

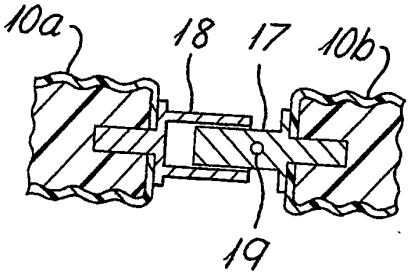

Fig. 3

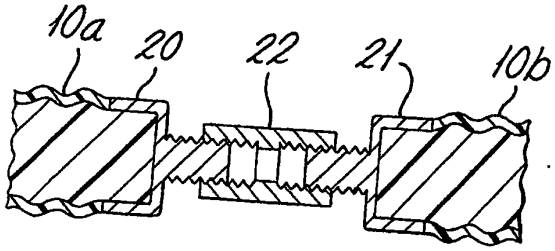

Fig. 4

SPECIFICATION

Orthopaedic fracture fixation apparatus

This invention concerns orthopaedic fracture fixation apparatus, and more particularly such apparatus of the kind comprising one or more elongate members which are located externally of the patient and are connected with bone pins secured in the different fragment of the fractured bone, the members and pins forming a rigid framework holding the fragments in a desired relationship for union.

Apparatus of this kind has recently become the subject of increasing interest and a number of different forms of the apparatus have been proposed and entered routine clinical usage in the last few years.

Earlier ones of these forms are relatively complex and involve a plurality of elongate members, universal and other couplings to allow multi-dimensional adjustment between the members and between the members and pins, and screw mechanisms to allow the application of tractive and distractive force across a fracture. Clearly these complex forms of apparatus are suited to use in a considerable variety of fracture situations, but they are correspondingly costly. This is particularly significant insofar as at least a major proportion of such an apparatus is committed to a patient to whom it is applied until the relevant fracture is well united.

More recent forms of the kinds of apparatus in question take account of the fact that the more commonly occuring fracture situations involve the long bones of the limbs and can be treated with simpler apparatus. These simpler forms of apparatus generally involve one elongate member for location alongside the limb with pins projecting from the member into the bone, or two such members along opposite sides of the limb with pins extending between the members by way of the bone. The scope for adjustment is usually limited and there is a consequent need for accurate positioning of the pins when securing the same in the bone, the pins typically requiring location in a substantially parallel array.

Other more recent forms seek to alleviate this last need for accurate pin positioning relative to the bone and member by the use of acrylic bone cement to connect the pins to an elongate member. Such connection allows some degree of variation in relative positioning between individual pins and the member without the added complexity and cost of adjustable mechanisms as intermediaries. However, the scope for such variation is still constrained by the use of a rigid member of preformed shape.

An object of the present invention is to provide yet another form of apparatus which can be simple but also open to very wide variation in pin-member positioning.

According to the present invention there is provided orthopaedic fracture fixation apparatus of the above-mentioned kind in which said elongate member comprises a tube or other elongate carrier of flexible form and charged with a hardenable material, such material normally being held by the carrier in an inactive fluent state.

In the further discussion of the present invention hereinafter, reference is made to the accompanying drawings in which:—

Figure 1 schematically illustrates, partly in section, one embodiment of apparatus produced in work leading to the invention, and also according to the invention; and

Figures 2, 3 and 4 schematically illustrate in section respectively different modifications of the embodiment of Figure 1.

Initial work leading to development of the invention has involved the used of a corrugated tube of flexible plastics material charged with bone cement immediately prior to use. In use, this tube is located to be pierced by the projecting ends of the associated bone pins after the latter have been secured with the bone fragments and the fragments suitably manipulated to a desired relationship.

In Figure 1 this situation is represented by the tube 10 which is charge with bone cement or other hardenable material 11 and pierced by the projecting ends of bone pins 12 secured in a fractured bone 13.

While this initial practice has been satisfactory insofar as the charged tube is initially flexible to accommodate to a great variety of pin positions and thereafter hardens to provide, with the pins, a rigid framework, there is some practical disadvantage. A particular disadvantage is that the bone cement must be mixed and applied to the tube, and the tube then closed before application of the charged tube to the pins. This is a time-consuming procedure relative to the rate at which bone cement hardens and the surgeon may, as a consequence, have too little time to locate the tube and to effect any final manipulation of the bone fragments.

This disadvantage is at least partially obviated by the provision of a carrier which is already charged. In addition, this disadvantage can be further obviated by the use of a hardenable material for which the hardening action is readily delayed until required. The material may also be one for which the hardening action can be accelerated by artificial means when required.

For example, use may be made of a material which hardens in response to light, visible or otherwise, in which case the charged carrier can be suitably enveloped in an opaque outer covering which is readily removed to initiate hardening. Such a material may in fact be slow to harden in normal light and be subjected to accelerated hardening after final positioning of the carrier. Different materials which harden in response to other forms of radiant energy, such as heat, may also be suitable. These examples are effectively illustrated by Figure 1.

Material which hardens by chemical action may also be employed. In one form of the invention suited to such action, use is made of a tube having two or more compartments for different

constituents of the hardenable material, such as epoxy resin and hardener, or cement powder and solvent, the compartments being separated by a thin wall which is rupturable upon squeezing the tube to mix the contents. In another form, the tube may be charged with one constituent, and the other is added by syringe injection for mixture by subsequent squeezing.

Also, while reference has been made to the use use of a carrier tube, other forms of carrier can be employed, such as an elongate permeable rope or tape suited to impregnation with the hardenable material.

A further point to note is that although the invention resides in the use of a flexible, hardenable member in place of the prior rigid elongate member, benefit can be gained from the use of members and adjustment mechanisms according to the prior art with application of the present member thereafter to release the initial members and mechanisms for use in relation to other patients.

Turning to the modifications of the remaining figures of the drawings, Figure 2 illustrates a modification in which the tube 10 is not coupled directly with the bone pins 12, but is indirectly coupled by a terminal structure 14 which is itself coupled with the tube and serves to clamp the free end of the pin. In the present example the structure 14 comprises a socket 15 and a screw 16 threadably engaged therewith, the socket receiving a pin end to be clamped by the screw. Clearly alternative structures can serve the same purpose. Such terminal structures can be advantageous if sealably connected with the tube 10 so that escape of hardenable material is avoided by piercing or other manipulation during use.

Figure 3 illustrates a modification in which the tube is provided in two parts 10*a* and 10*b*. Each tube part is connected at one end with one of two terminal parts 17 and 18 respectively of cooperable piston and cylinder form. Each of these terminal parts is preferably sealably connected with its tube part, and interfaces with the material therein to form a unified rigid structure upon hardening of the material.

The modification of Figure 3 is intended for use in connection with a long bone of a limb and, in such use, the tube parts are to be located on opposite sides of the fracture with the terminal parts aligned generally longitudinally relative to the bone, with the terminal parts mutually engaged, but not fully so. This arrangement will serve to assist in maintaining alignment of the bone at the fracture while the latter unites, and also allows compressive loading of the fracture in a natural manner by use of the limb. In order to ensure that the terminal parts are not fully engaged when applying the apparatus and during the ensuing hardening, a removable stop mechanism can be provided such as a transverse pin 19 in the piston part as shown in Figure 3.

The modification of Figure 4 is generally similar to that of Figure 3 but with terminal parts 10 and 21 having screw projections of mutually opposite thread in place of piston and cylinder formations. These parts 20 and 21 can be coupled by a sleeve 22 having respectively opposite, internal threading complementary with that of parts 20 and 21 whereby, after hardening of the tube parts, compressive or distractive force can be applied across the fracture by appropriate rotation of the sleeve.

CLAIMS

1. Orthopaedic fracture fixation apparatus of the kind including at least one elongate member located externally of the patient and connected with bone pins secured in the different fragments of a fractured bone, the member and pins forming a rigid framework holding the fragments in a desired relationship for union, wherein said member comprises an elongate carrier of flexible form and charged with a hardenable material, such material being normally held by the carrier in an inactive fluent state.

2. Apparatus according to Claim 1 wherein said carrier comprises a closed tube having its interior charged with said material.

3. Apparatus according to Claim 1 wherein said carrier is of permeable form charged with said material by impregnation.

4. Apparatus according to Claim 1, 2 or 3 wherein said material is hardened in response to radiant energy.

5. Apparatus according to Claim 4 wherein said energy is light.

6. Apparatus according to Claim 5 wherein said carrier has a separable covering opaque to said light.

7. Apparatus according to Claim 4 wherein said energy is heat.

8. Apparatus according to Claim 2 wherein said material is chemically hardened by mixture with a further fluent material.

9. Apparatus according to Claim 8 wherein said tube is divided by a rupturable wall into separate compartments respectively charged with said material and further material.

10. Apparatus according to Claim 2 or any claim dependent thereon comprising a plurality of clamp assemblies distributed along and penetratably sealingly connected with said tube, said assemblies each being adapted to clamp a respective bone pin.

11. Apparatus according to Claim 2 or any claim dependent thereon wherein said tube is in two separate longitudinal parts interconnected by a longitudinally adjustable mechanism.

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